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Marine Research
1955 No. 1

The Plankton of the Waters Approaching the British Isles in 1953

By J. H. FRASER, D.Sc., Ph.D., F.R.S.E.

EDINBURGH: HER MAJESTY'S STATIONERY OFFICE
1955

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The Plankton of the Waters Approaching the British Isles in 1953

ABSTRACT

The plankton communities of the incoming oceanic water masses off the coast of the British Isles are differentiated. 953 evidence indicates that the 'Lusitanian' fauna, partly of Mediterranean origin and containing a number of character-pecies was much more extensive than in previous years. Its course is traced off the south west of Ireland, west of nd both east and west of Rockall, and via the Faroe-Shetland Channel to the northern North Sea.

his fauna was associated with a scarcity of crustaceous plankton and may have contributed to the failure of the Shetland g fishery and if prolonged it might affect the potential fish production of the northern North Sea.

INTRODUCTION

The main routes of inflow of oceanic water into the area round the British Isles have now been well established. There are considerable annual and sub-annual variations in the strength of each several systems that contribute to the whole, so that the proportion of the water coming from each different regions of origin is very variable. This results in complex hydrographic conditions in the n of intermixing, which in turn affect the biology of the area. Indeed Tåning (1953) has emphasised strongly the possible effects of hydrographic changes in the area west of the British Isles on the ies of the whole arctic region of the Atlantic Ocean. The main sources of oceanic inflow may be y summarised.

The most important source is the North Atlantic Drift Current, part of which flows north-east gh the Faroe-Shetland Channel and along the Norwegian coast towards the Bear Island area. enerally confined to about the upper 600 metres as it approaches the British Isles; and the volume water transport varies greatly within each year and also from year to year. A branch of this stream s the North Sea round the north of Shetland and the strength of this branch also varies, not neces- in accordance with the major variation through the Faroe Channel. In some years—e.g., 1935 1936)—the main Atlantic stream embraces the entire group of the Faroe Islands: at other times an influence mixes with a subsidiary oceanic stream to the west of Faroe or acts as a barrier across aroe-Shetland Channel to prevent or reduce the continuation of the flow of Atlantic water towards ay (Tait 1949).

outflow of subsurface water from the Mediterranean mixes with water in the Gulf of Gibraltar although the mixture gradually becomes diluted, it retains some of its original Mediterranean and characteristics as it continues northward towards the Celtic Sea and towards Rockall, underlying tlantic water from the west (Cooper 1952). It then apparently follows the edge of the Hebridean nental Shelf, mixing on its western edge with open oceanic water, and upwells somewhat on the ide to overflow and mix with coastal water on the shelf. In some years this current may not reach nd or is too weak to be recognised, but on occasions it is sufficiently strong to continue into the side of the Faroe Channel, though it only rarely penetrates beyond the north of Shetland. Fre-ly, however, it mixes with the coastal water on the shelf and the resulting mixture floods the area west of Orkney and often passes through the Fair Isle-Orkney Passage into the Moray Firth area r 1952).

The whole of this oceanic system to the north and west of Scotland overlies a south tending mass of or boreal water. The main flow of this water mass is to the west of Faroe from whence it thrusts wards in deep water (below about 1000 m.), but part also penetrates the Faroe Channel where it cked by the Wyville Thomson Ridge. Although this water affects the inflowing system where it at its interface it is not of such importance as are the more massive cold water currents on the other f the Atlantic.

Each of the above water masses has a typical plankton fauna (see Russell 1939, and earlier works), t varies within certain limits, in the abundance and in the proportions of its constituent species

from year to year. As these organisms are transported further from their natural habitat they gradu die as their limit of tolerance is reached, and they are replaced by other species through mixing either other oceanic streams or with coastal water. The fauna of an incoming water mass thus gradually cha along its length; for example, few of the oceanic species noted off Scotland normally reach north-we Norway (Wiborg 1954). The degree of survival of the original fauna gives a measure of the puri the inflow, and the relative life of the species less tolerant to various factors may give an indicatio the type of dilution or change involved. Plankton samples taken by the Scottish research vessels ov number of years have now been examined and reports referring to this theme have appeared ann in Annales Biologiques, and in several papers in which correlations with specific hydrographic condi have been attempted (quoted in Fraser 1952).

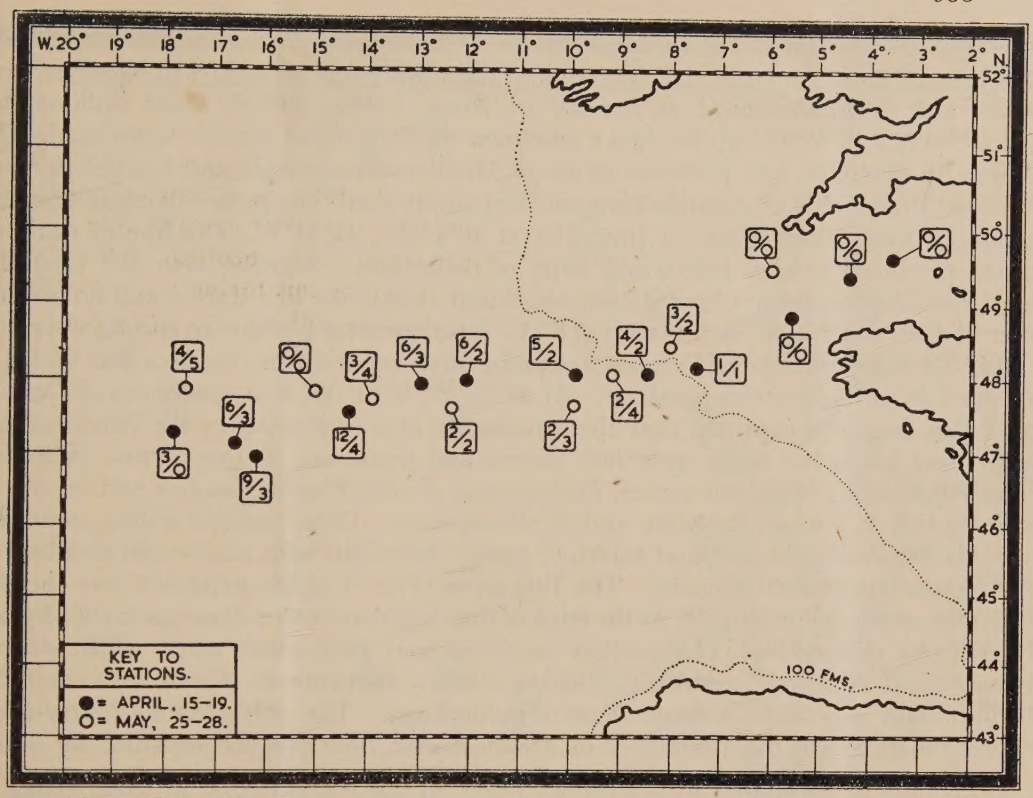
CONDITIONS OFF THE SOUTH-WEST OF ENGLAND

Investigations off the Iberian peninsula by Fleury (1953b) and by the Continuous Recorder s of the Scottish Marine Biological Association at Edinburgh (e.g. Rae 1953 and earlier papers) have g much needed information about recent conditions in or near the areas of origin of the 'Lusitanian' fa 'Lusitanian fauna' is here defined as that fauna which, originating in the outflow from the Mediterran has become modified by admixture with fauna from the area between the Azores and Bay of Bi It thus corresponds to the fauna of the mixed Central and Gibraltar Water rather than to that o capsized and cascaded water—see Cooper (1952) p. 504. It is used as a convenient term to disting it from the fauna of the North Atlantic Drift on the open Atlantic to the west of the British Isles– North Atlantic Central water of Cooper (1952). A number of oceanic species are common to both although some are found only in the Lusitanian stream, there are few, if any, entirely confined t North Atlantic Drift. Thus the distinguishing feature of the fauna of the latter is the presence o cosmopolitan oceanic species, at times reinforced by an admixture of boreal forms, but without an app able representation of the Lusitanian species. A list of some of the more important species is give Page 12, which is very far from exhaustive, especially in the Calanoid copepods, but which neverth contains sufficient information to distinguish the two communities. During 1953 the data have augmented by the following collections made from H.M.S. *Challenger* off the entrance to the En Channel by Surgeon-lieut. Campbell, to whom I am greatly indebted:

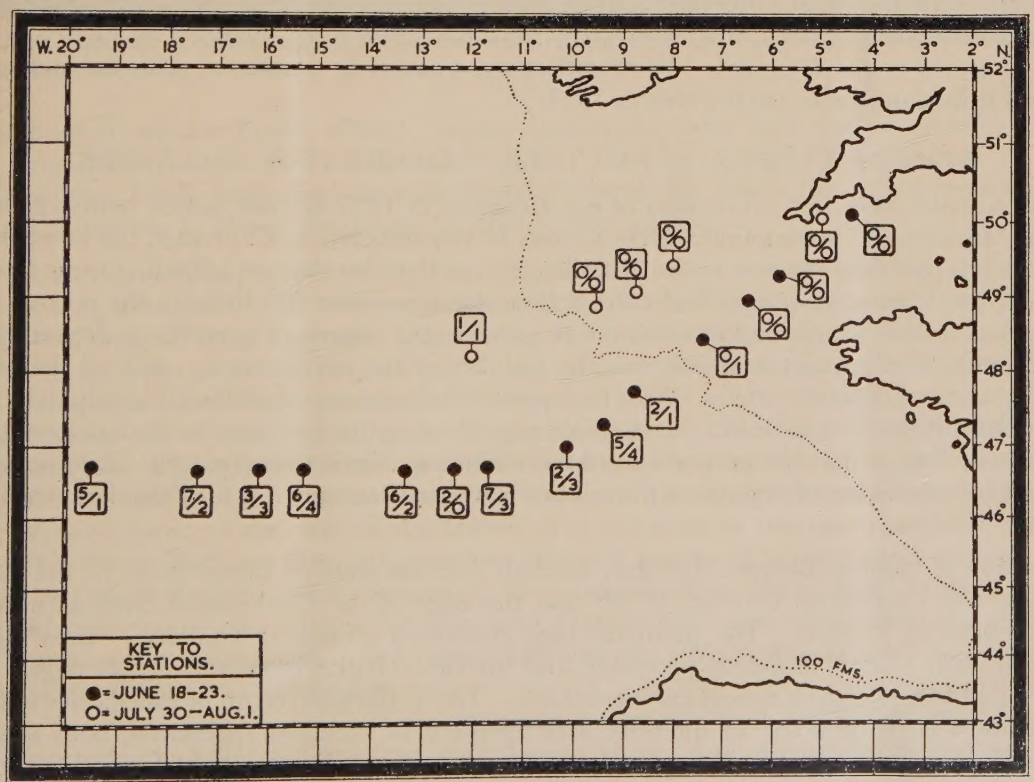
1. 15-19 April	12 stations, 49°39′N., 03°30′W. to 47°16′N., 17°52′W.
2. 25-28 May	8 stations, 47°50′N., 17°40′W. to 49°28′N., 05°52′W.
3. 16-23 June	14 stations, 50°08′N., 04°25′W. to 46°46′N., 19°37′W.
4. 30 July-1 Aug.	5 stations, 48°15′N., 11°59′W. to Falmouth Bay.

These collections, together with the Scottish samples taken further north, have yielded some ticularly interesting results which show that the Lusitanian component was particularly marked in and penetrated well into Scottish waters.

This was first noted in the April collections of the "Challenger" (see Fig. 1), which showed a distinct change from typical coastal plankton in the Celtic sea to oceanic plankton over the deeper w This oceanic plankton contained many species of general oceanic occurrence, such as *Salpa fusif Dimophyes artica, Chelophyes appendiculata* and *Eucalanus elongatus,* but with a large proportion of Lusita forms, particularly the siphonophores *Bassia bassensis, Praya cymbiformis, Rosacea plicata, Eudoxoides sp* and *Hippopodius hippopus,* and also *Velella velella, Sagitta lyra, S. serratodentata var. tasmanica* (see Furn 1953) the polychaetes *Vanadis formosa, Callizona angelina, Sagitella kowalewskii,* and the medusae *Rhopal velatum* and young stages of *Pelagia noctiluca.* Of special interest is the record already published (F 1954, 1955) of the occurrence of the salp *Ritteriella picteti* at 47°31′N., 14°21′W., which had never previ been reported from the north temperate Atlantic. This Lusitanian fauna was densest betwee and 16°W. and was much reduced west of 16°30′W.



The positions of the "Challenger" stations in April and May, 1953. The figures associated with the positions indicate the number of species named in the table; the upper figure represents species named in column 1, and the lower figure those in column 2, i.e., the higher the "fraction" the greater the proportion of Lusitanian forms.



The positions of the "Challenger" stations in June and July-August, 1953—See also legend to fig. 1.

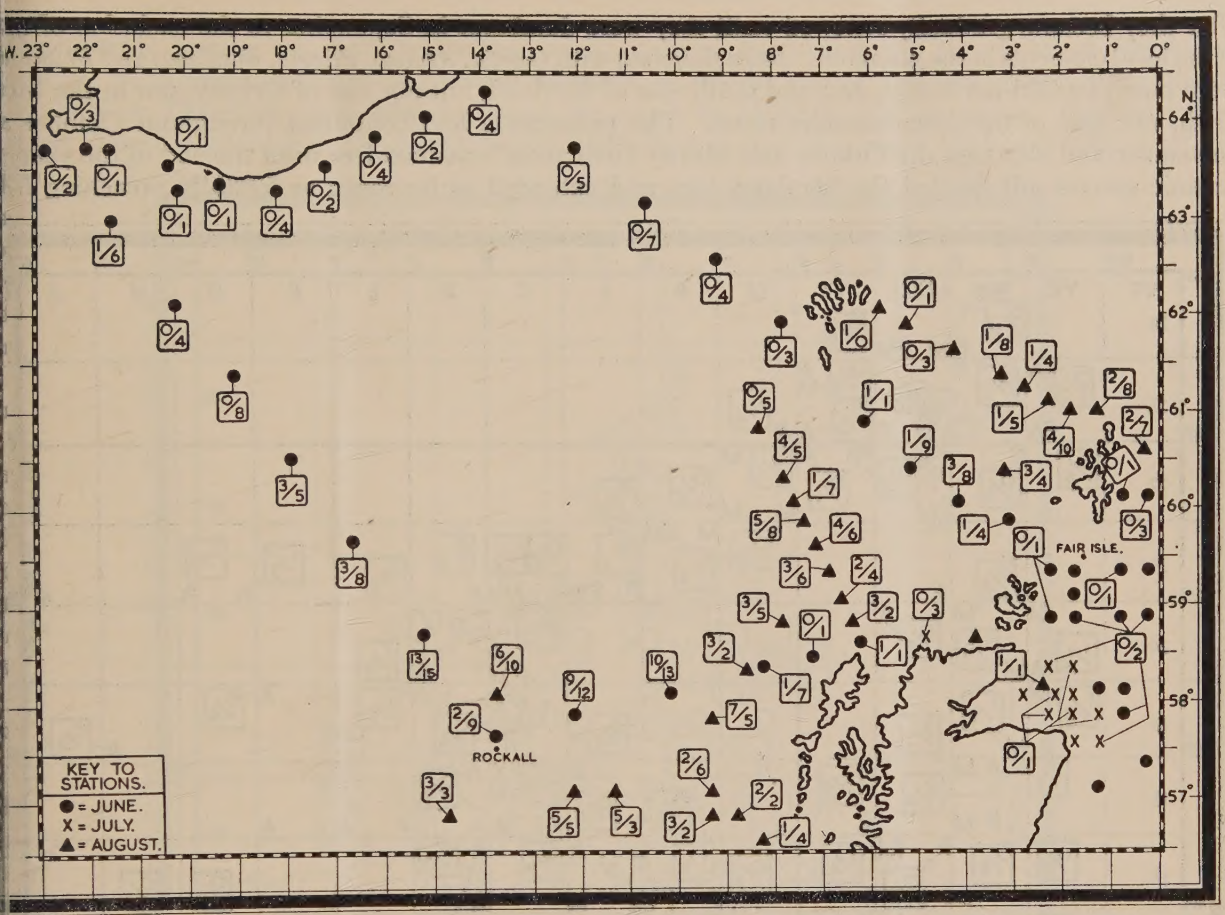
By May (Fig. 1), this fauna, as sampled by the "Challenger", had changed considerably; *fusiformis* had become more generally distributed, and there were several species of *Sapphirina*—*S. an* *S. nigromaculata* and *S. ovatolanceolata*, as defined by Rose (1933)—though fewer siphonophores present. At 47°40′N., 13°58′W. an excellent specimen of *Ethmodiscus gazellae* was found. This diatom, 1.8 mm. in diameter, was probably of direct Mediterranean origin and has not previously found in this area (Fraser 1954). Another complete but empty shell (i.e., both valves) and several br bits of this diatom were taken again on June 21st at 46°45′N., 11°41′W. The line of stations in (Fig. 2) indeed produced a most interesting series of collections. Starting near the Cornish coa S.W. England, the Channel species *Sagitta setosa* was found at only the first station and no oceanic sp were found until deep water was reached west of 8°W., but thereafter Lusitanian species were found stations. These included numerous *Doliolum nationalis*, often reported in this area but which have yet been recorded from the Scottish plankton. At 47°22′N., 9°30′ W. four specimens of *Doliolina m* Krohn were taken and it is expected that these probably also originated in the Mediterranean. *Salpa fusiformis* were taken but there were *Iasis zonaria* and numerous siphonophores (including *B* *Eudoxoides* and *Hippopodius*), *Eucalanus crassus, Pleuromamma gracilis, Phaenna spinifera* and several spec Sapphirina, including *S, scarlata, S. opalina* and *S. nigromaculata*. Other copepods also occurred in numbers—*Calanus helgolandicus, Centropages bradyi, C. typicus, Aetidiopsis* with *Evadne* and numbers of R laria, chiefly *Acanthochiasma* and *Collozoum*. The July series (Fig. 2) barely extended over the deep and few Lusitanian species were found. At the edge of the shelf there was a dense patch of phytoplan particularly *Nitzschia delicatissima, Thalassiothrix longissima* and *Rhizosolenia alata*, whilst over the were numreous small copepods, especially *Oithona similis, Microcalanus, Paracalanus*, and *Centro typicus*. Off Falmouth was found a dense mass of ophioplutei. The only obvious "carry-over" o oceanic species from June was the abundance of *Acanthochiasma*, here also accompanied by *Acanthom*

These results may be compared with those recorded off the Iberian coast in June, 1952, by F (1953b), who also gives details of the copepods at the entrance to the Channel in May 1949 (19 There are a number of species in common between those found in 1953 by the "Challenger" an Iberian species of Fleury in 1952, but in 1953 when oceanic species were dominant there was o small copepod content, at least until July, although there were a number of species of Sapphirina v are associated with warm water. It is noteworthy that this genus is not included by Fleury in her list for the entrance to the Channel. These differences can all be associated with an increase i transport of Lusitanian species northwards in 1953.

CONDITIONS OFF THE SCOTTISH COASTS

Scottish samples were first taken west of the Hebrides in 1953 in June, when many of the sp taken by the "Challenger" were found. Here it must be remembered that although the Scottish sa were very much larger than those from the "Challenger", so that the chances of finding rarer species much greater, the Lusitanian stream had carried the organisms some 700 miles to the north. Ma the less tolerant species would be lost during this passage, the degree of persistence depending o volume and strength of water transport—i.e., the stability of the environment—and on the amou its dilution by water of different origin. With the approach of summer conditions it is only to be exp that those forms sufficiently tolerant to thrive would reproduce in the new area, as distinct from thos would merely survive, so that the proportions of the various species is thus changed. Additional ch is also caused by admixture of organisms from other water masses, and much of this fauna will als produce.

On the line of stations between Iceland, Rockall and the Butt of Lewis (Fig. 3), the Lusita fauna in 1953 was continuous between 16°W. and the edge of the Continental Shelf at about 9 i.e., on both sides of Rockall. The plankton here contained abundant Thaliacea—*Ihlea asymme* *Salpa fusiformis, Iasis zonaria, Dolioletta gegenbauri*, and the rare Mediterranean *Cyclosalpa virgula* of w three solitary and two aggregate specimens were taken. This is the first record of this species so far n *Ihlea asymmetrica* was reproducing in quantity and consisted of excellent specimens, both solitary aggregate forms, in contrast to most years when only the disintegrated remains are found in Irish (Fa



3 The positions of Scottish plankton collections in June, July and August, 1953—See also legend to fig. 1 (The symbol $^{0}/_{0}$, for absence of either, is omitted in figs. 3, 4 and 5).

) or Scottish waters (Fraser 1949a). Other Lusitanian forms here were *Eudoxoides, Vogtia, Bassia, cea, Hippopodius, Rhopalonema, Nausithoe, Pelagia, Travisiopsis, Sagitta serratodentata v. tasmanica, S. S. bipunctata, Vibilia pyripes* and the radiolarian *Thalassiocolla*. This is the second record of *S. bipunctata* n Scottish waters, as it was also found in 1949 (Fraser 1949b).

Although this rich Lusitanian fauna—the richest of the year—was not sampled west of the Hebrides l June, it is clear from other observations that these June collections did not represent their earliest val in this area. Plankton samples taken in the Faroe Channel in February, March, April, May and e (Fig. 4), showed that the Lusitanian species passed through in increasing numbers, starting in March n a few specimens of Hippopodius and Praya were found off the Butt of Lewis, and reached the iediate north-west of Shetland in April. The numbers both of individuals and of species in the Faroe nnel increased in May and reached a maximum in June. Species such as *Periphylla, Vogtia* and *Rosacea* appeared in May but the Thalicea were not found until June. By August (Fig. 3), the numbers had me much reduced to the west of the Hebrides as the peak of the wave passing to the north and hing the Faroe Shetland line in September (Fig. 5), produced a progressive increase in Shetland ers from June onwards, which culminated in a maximum in September-October. Few doliolids hed Shetland though the salps *S. fusiformis* and *I. asymmetrica* were very abundant, the latter by this in a disintegrating condition. *Iasis zonaris* followed the edge of the shelf more closely and was last west of the Orkneys in September.

There had been little sign of oceanic influence in the northern North Sea until June. By then nic species that had lingered from the big inflow of the previous autumn had disappeared, but there-

after they became gradually renewed until they were dominant in September to the exclusion of ma of the local elements in the plankton. *Salpa fusiformis* with *Galetta, Agalma, Pelagia, Eucalanus* and *Rhincala* were then plentiful north-east, east and south-east of Shetland, but not east of Orkney, nor in the Mo Firth, nor east of the Aberdeenshire coast. The progression had continued throughout October a November and although the Orkney and Moray Firth areas remained free until the end of the year, oceanic species still flooded the Shetland area and extended as far south as 57°30′N., reaching 57

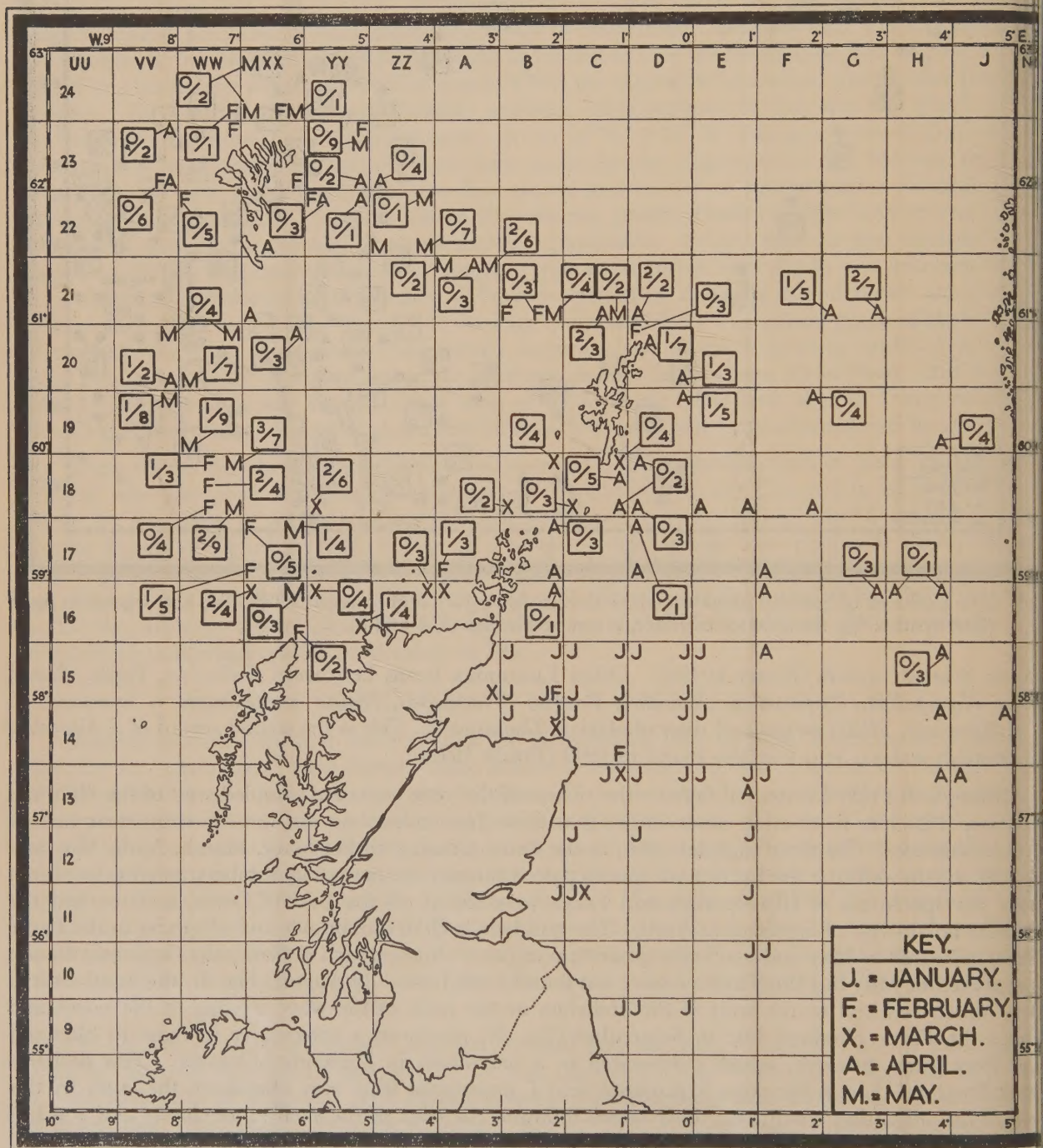
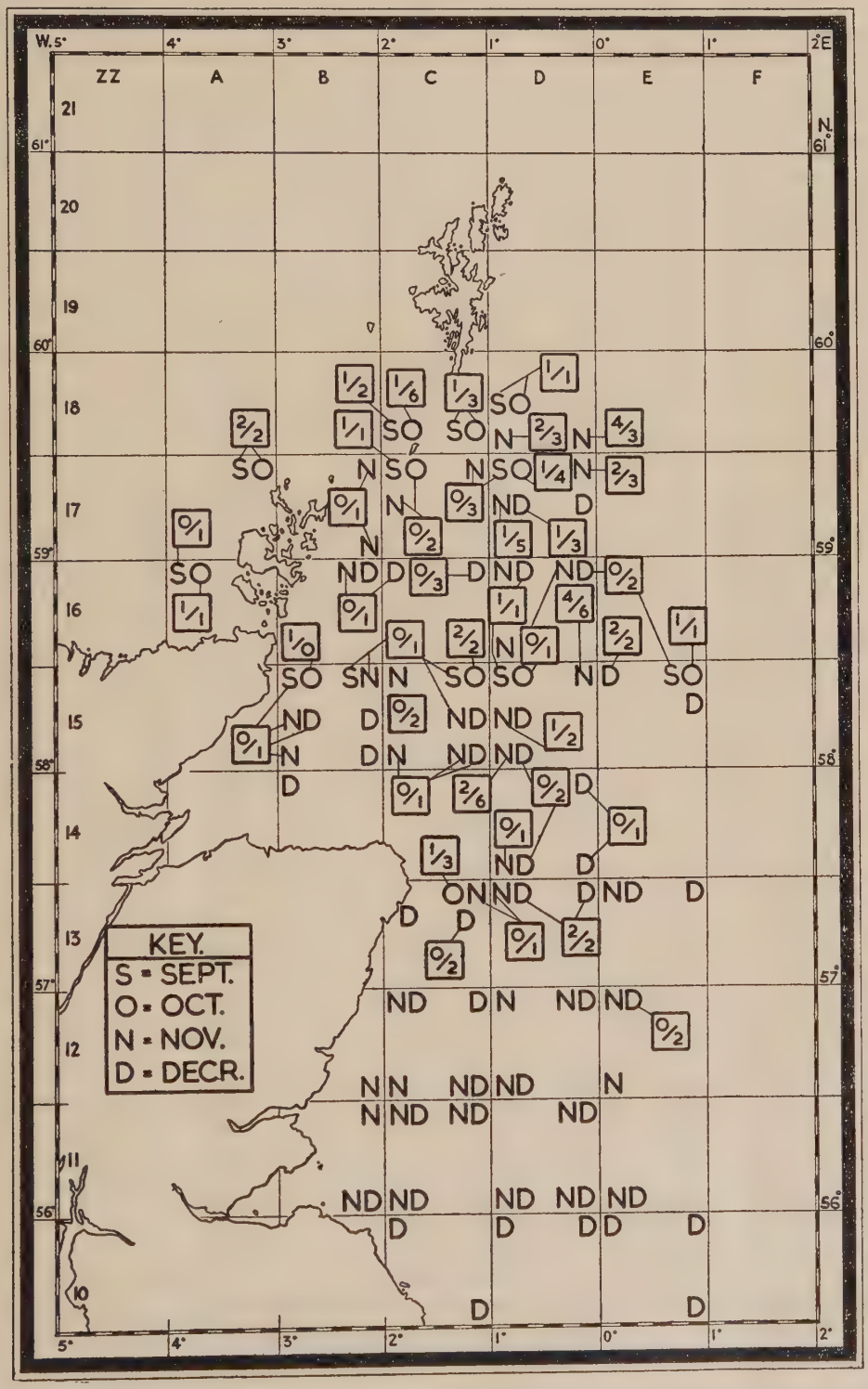


Fig. 4 The position of the spring collections, January-May, 1953. Positions are given only to the nearest s square—See also legend to fig. 1.

December. Among the more interesting of the species penetrating into the northern North Sea e found an excellent specimen of *Phronima sedentaria*, in its case, east of Fair Isle in November, *Sagitta* at 59°N. in December, and *Rhopalonema* as far south as 58°30′N. in November. *Fieraster* larvae urred more abundantly in the North Sea in 1953 than in any year since 1904 and 1905, and five



5 The position of the autumn collections, September-December, 1953.—See also legends to figs. 1 and 4.

larvae were taken in a single haul in 59°40′N., 0°30′W. in October. They occurred fairly frequen first found in June between Faroe and Orkney, and reached their greatest abundance east of Fair in September, October and November, reaching as far south as 57°25′N., 0°20′W. and 57°25′N., 1°20 in December. *Pelagia noctiluca* increased in numbers from June onwards in this area, and by e November was abundant enough to interfere with fishing operations west of Shetland. It replaced usual jellyfish, *Aurelia*, which however was still present in those areas not affected by the inflow, Moray Firth.

A most unusual siphonophore for this area, identified for me by Captain A. K. Totton as *Apole uvaria* (Lamarck), can also be regarded here as a Lusitanian species. Found first in August to the no west of the Butt of Lewis, 58°51′N., 7°35′W., north-west of Orkney, 60°30′N., 3°09′W., and immedia east of Shetland, 60°12′N., 1°18′W., it was later found in October and November in five localities of Fair Isle as far east as 0° and in the North Sea as far south as 58°25′N., 0°20′W. Like *Pelagia* and o Lusitanian indicators, it was not found in the Moray Firth.

The oceanic fauna not only contained the indicator species mentioned but included a large propor of general oceanic species, with the consequent reduction of the rich mixed fauna usually associated v this area, and with fewer boreal species. *Calanus finmarchicus* had been fairly common in the north North Sea prior to the inflow but was pushed southwards to be unusually abundant south of ab 57°30′N. Round the edges of the oceanic area in the North Sea were large concentrations of young st of euphausids, *Thysanoessa inermis* to the west, near the Scottish coast and *Nyctiphanes couchii* with s *T. raschii* and *T. longicaudata* to the south, east and north-west. Large numbers of *Pleurobrachia* w found near Orkney and in the Moray Firth in autumn, and off the east Scottish coast in Novem *Limacina* was fairly widespread and reached dense concentrations particularly off the Firth of Fort November. The paucity of crustaceous plankton in association with the oceanic inflow coincided v the failure of the herring fishery off Shetland. This fishery, which started in May with ordinary prosp failed unexpectedly in June, i.e., about the period of the first arrival of the Lusitanian fauna, and did recover. An explanation of this failure might be found here; either that the herring were directly rep by these conditions which were sufficiently abnormal to prevent the indigenous species of plankton f following their usual development on admixture, or that the absence of the usual food value in the plan made them seek food elsewhere. A prolonged scarcity of crustaceous plankton in this area would h serious effects on the potential fish production in the northern North Sea.

The paucity of *Calanus* and other organisms of rich food value in the oceanic area was not recorded in the northern North Sea, but was abundantly evident in the whole Faroe-Shetland area a about May, and after March between Faroe Bank and the Butt of Lewis. *Calanus*, etc., was com enough between Faroe Bank and Faroe, and between Faroe and Iceland especially west of 10°W. T is some evidence of oceanic plankton penetrating northwards to the west of Faroe east of 10°W., an this area *Calanus* was less abundant. A line of stations from south-west Iceland (Reykjanes) to Rocka June did not meet with a high proportion of Lusitanian forms until east of 16°W., as stated earlier, bu all stations after leaving the Icelandic shelf oceanic species dominated the plankton. These inclu *Agalma, Arachnactis, Physophora, Chelophyes, Halicreas, Pantachogon, Clio pyramidata* etc., though it is signifi that underlying the upper 250 metres there was a suspicion of Lusitanian admixture as far as 2 where some disintegrating *Ihlea asymmetrica* and *Hippopodius* were found. Interesting records are of the medusa *Bythotiara murrayi* and the polychaetes *Lopadorhynchus unicinatus* and *Harmathoe bentho* all at 60°32′N., 17°55′W., below 250 m., and larval stages of the fish *Nansenia groenlandica* which v found both in this area and the Faroe Channel. This western Atlantic fauna continued eastwa presumably north of Rosemary Knoll, to reach the north side of the Faroe Channel where it intermi with and became lost in the dominant southern fauna.

Although the Lusitanian stream off the west of the British Isles is primarily a sub-surface infl its effects appear in the surface layers as shown by the I.C.E.S. surface temperature charts for the y For example, the main inferences of this paper can be seen reflected in the positions of the 11° and isotherms in the Rockall area in June and July 1953 compared with those of 1952, and in the posi of the 11° isotherm in the Shetland area in September. It is probable that the very open winter conditi in the Scottish area during the last months of 1953 were associated with this inflow.

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TABLE I

List of some characteristic organisms that can be used to distinguish the 'Lusitanian' fauna from that of the North Atlantic Drift.

	Column 1 LUSITANIAN FAUNA	Column 2 COSMOPOLITAN OCEANIC SPECIES
Siphonophora Medusae, etc.	*Rosacea plicata*, Q. and G. *Praya cymbiformis* (Delle Chiaje) *Nectopyramis diomedeae* Bigelow *Nectopyramis thetis* Bigelow *Bassia bassensis* (Q. and G.) *Vogtia*—all species *Hippopodius hippopus* (Forskål) *Muggiaea spp.* *Eudoxoides spiralis* (Bigelow) *Chuniphyes multitentaculata* Lens and Van Riem *Lensia*—all species except *L. conoidea* *Stephanomia bijuga* (Delle Chiaje) *Apolemia uvaria* (Lamarck) *Velella velella* (L.) *Rhopalonema velatum* Gegenbaur *Nausithoe punctata* Kölliker *Pelagia noctiluca* (Forskål)	*Physophora hydrostatica* Forskål *Agalma elegans* (Sars) **Nanomia cara* Agassiz *Dimophyes arctica* (Chun) *Galetta biloba* (Sars) *Lensia conoidea* (Kerf. and Ehl.) *Chelophyes appendiculata* (Esch). Arachnactes larvae *Halicreas spp.* *Pantachogon rubrum* Vanhöffen *Periphylla periphylla* (Peron and Les.) **Laodicea undulata* (Forbes and Good.) *Cosmetira spp.* **Halopsis ocellata* Agassiz
Chaetognatha	*Sagitta lyra* Krohn *S. serratodentata tasmanica* Thomson *S. bipunctata* Q. and G. *Krohnitta subtilis* (Grassi)	*Sagitta planctonis* Steinhaus *S. serratodentata atlantica* Tokioka **Eukrohnia hamata* (Möbius) *S. hexaptera* d'Orbigny **S. maxima* (Conant)
Annelida	*Travisiopsis spp.* *Lagisca hubrecti* (McIntosh) *Vanadis formosa* Claparede *Callizona angelina* (Kinberg) *Sagitella kowalewskii* Wagner	*Tomopteris septentrionalis* Apstein
Pteropoda, etc.	*Clio polita* (Craven) *Janthina britannica* Forbes and Hanley	*Clio pyramidata L.* *C. cuspidata* (Bosc) *Diacria trispinosa* (Lesueur)
Crustacea	*Nematoscelis megalops* G.O. Sars *Stylocheiron spp.* *Vibilia spp.* *Phronima spp.* *Sapphirina spp.* Phyllosoma larvae	*Meganyctiphanes norvegica* (M. Sars) **Thysanoessa longicaudata* (Krøyer) *Rhincalanus nasutus* Giesbrecht *Eucalanus elongatus* Dana
Thaliacea	*Cyclosalpa spp.* *Ritteriella spp.* *Thalia democratica* (Forskål) *Thetys vagina* (Tilesius) *Iasis zonaria* (Pallas) *Ihlea asymmetrica* (Fowler) *Salpa maxima* Forskål *Doliolina mulleri* Krohn *Doliolium nationalis* Borgert	*Salpa fusiformis* Cuvier †*Dolioletta gegenbauri* ((Uljanin)

*Species with boreal associations not as likely to occur in Lusitanian communities.
†Of cosmopolitan oceanic distribution but very often associated with Lusitanian fauna.

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